PRGR 603
Solar Radiation & Energy Conversion

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Academic Degrees:
BSc. Mech. Power Eng. , Cairo University, 1970
MSc. Mech. Power Eng., Cairo University, 1973
Ph.D, Imperial College, London, 1977; DIC, Imperial College London, 1978

Fields of Interest and Research:
Renewable Energy particularly Solar, CFD, HVAC, Heat Transfer, Environmental engineering

CATEGORY: Required Energy Specialization online course

NUMBER OF CREDITS: 2 Cr.

PREREQUISITES BY TOPIC:
University level heat transfer, thermodynamics, trigonometry and calculus.

COMPUTER USAGE PROFICIENCY:
Proficiency in use of EXCEL or MATLAB

TEXTBOOK AND REFERENCE MATERIAL:
i) Solar Engineering of Thermal Processes, John Duffie and William Beckman, John Wiley & Sons, Inc., 3rd edition
ii) Solar Energy Engineering: processes and systems, A. Soteris, U. Kalogirou, Elsevier, AP, 2nd edition.
iii) Renewable Energy Resources, John Twidell and Tony Weir, publisher Taylor & Francis, 2nd edition.
iv) Lecture notes

COURSE INTRODUCTION

COURSE TITLE: Solar Radiation and Energy Conversion
PREPARED BY: Amr Serag-Eldin

COURSE GOALS:
Course provides a comprehensive analysis of solar thermal energy collection and conversion with equal emphasis on both the solar radiation characteristics and the solar energy conversion devices.

Catalog Description: Characteristics of solar radiation and relative motion of Earth and Sun; beam incidence angles; sun-path diagrams and collector shading; clear sky models; isotropic and anisotropic diffuse radiation models; utilizability. Solar thermal energy conversion with emphasis on the design, performance and selection of solar thermal technologies such as: tracking and stationary solar concentrators, solar water heaters and systems, solar thermal power plants, solar ponds, and solar updraft towers.

COURSE OBJECTIVES:
The main objective of the course are:

i) To be able to estimate the incident solar energy on a collector surface of arbitrary inclination. Students learn the basic motions of the sun and earth which result in the wide variation of solar energy intensity in both space and time. They learn to calculate the beam radiation incident angles at any surface for any location and time. They learn models for both diffuse and beam components of radiation on tilted surfaces, and how to estimate effects of collector shading, as well as assess the "utilizability" of the solar energy.

ii) To be able to design, size, and select solar thermal technologies such as: solar water heaters and systems, solar concentrators, solar thermal power plants, solar ponds, and solar updraft towers. Students learn the advantages and disadvantages of each application, the current state of the art, new improvements and future trends. They are exposed to practical implementations including hybrid solar and fossil systems.

COURSE OUTCOMES:
Upon completion of the course, students should be able to:

1. Describe the relative motions of the Earth and sun and their effect on the variation of Solar energy with time and location; calculate accurately the incidence angle of the beam component of radiation on an arbitrarily inclined plane
2. Apply solar radiation clear sky and diffusion models to predict the solar radiation intensity at any collector surface, and its breakdown into diffuse and beam components.
3. Estimate the utilizable energy for a given application and period and use excel spread sheets and/or MATLAB to make solar energy resource estimations.
4. Analyze, perform basic design calculations, and estimate thermal losses and efficiency for flat plate collectors and stationary parabolic concentrators.
5. Analyze, perform basic design calculations, and estimate both optical and thermal efficiencies for concentrated parabolic trough collectors
6. Analyze and make basic estimates for performance of solar ponds and updraft towers
7. Describe how parabolic trough concentrators, Fresnel mirror collectors, parabolic dish concentrators and solar power towers are currently employed to produce electricity in power plants , and list the advantages, disadvantages and limitations of each system
8. Design both active and passive solar heating systems

TOPICS:	Lectures
Module 1: Introduction to course	1
Module 2: Basics of Solar Radiation	4
Fundamentals and characteristics	
Extra Terrestrial radiation	
Components	
Geometry of Earth and Sun	
Geometry of Collector and Beam	
Solar time and civil time	
Angles for tracking surfaces	
Collector shading	
Module 3: Solar radiation, measurements, models & data	3
Effect of atmosphere	
Effect of Latitude and season	
Hourly variation of Irradiance	
Solar radiation measurements	
Solar radiation models	
Solar radiation Data	
Module 4: Radiation on collectors	4
Review of Radiation HT	
Radiation on Inclined Surfaces	
Isotropic Model	
Anisotropic Model	
Utilizability	
Module 5: Stationary collectors	5
Review of conductive &convective HT	
Flat plate collector	
Evacuated tube collector	
Compound parabolic collector	
Module 6: Concentrating and tracking collectors	3
Advantages/disadvantages of concentration	
Parabolic trough optical analysis	
Parabolic trough thermal analysis	
Linear Fresnel reflectors	
Module 7: Solar Thermal Power	2
PTC Systems	
Solar tower systems	
Solar ponds	

Solar updraft towers

Module 8: Solar Water Heating systems	2
Passive systems	
Active systems	
Pool heating systems	

Total number of Lectures	24

ASSIGNMENTS:

Assignment I:	Principles of solar radiation & RE
Assignment II:	Solar radiation models
Assignment III:	Solar radiation incident on collectors
Assignment IV:	Flat plate and compound parabolic collectors
Assignment V:	Concentrators, solar ponds, updraft towers
Assignment VI:	Solar water heating systems

GRADING POLICY:

22 Quizzes	22 %
6 assignments	78 %
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Total	100 %

Notes:

i) Quizzes are presented at the end of each lecture, and will pertain to the material of the lecture only. They comprise only True/False questions; their objective is to keep students alert, and avoid postponing revision to the end of the module.

ii) Assignments follow at the end of each module, and cover all the material in the module. They are more demanding than quizzes and include lengthier calculations and case studies. Purpose is both to educate and evaluate. They are graded in two stages; first without assistance and then after assistance is provided. The average of the two attempts is recorded.

PROFESSIONAL COMPONENTS

Technology:	35 %
Modeling:	25 %
Mathematics and basic sciences:	20 %
Environment and sustainability:	10%

COMMUNICATIONS

By necessity online courses have different means of communication than face to face courses; they rely totally on online internet communication. The MOODLE software will be used for this purpose.
This software will also facilitate interaction, group discussions and grading.

Communication between lecturer and student could either be private or public. The lecturer will decide which is the most appropriate, case by case. For example a student may ask a question which the lecturer believes other students could benefit from, so he may post the reply to all; he may even open it to a group discussion.

To break the ice and kick-start the online communication process,
I will ask each student to publically introduce himself; they may like to use the following questions as a guide:

- Who are you?
- Which country do you live in?
- What is your occupation?
- What is the best way to contact you? What is your e-mail address?
- What are your main objectives for attending this course? and your
expectations of online learning?
- Have you attended an online course before?

You may also attach a photograph or CV of yourself if you wish, and/or add any other personal information which you feel relevant. The public introduction is optional, however, at least provide me in private with the information requested as it will assist me in improving the course delivery

P.S. Don't worry we will not exploit this information for marketing purposes!